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INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

METHOD AND COST OF MINING MAGNETITE IN THE MINEVILLE DISTRICT, NEW YORK

BY A. M. CUMMINGS

CONSULTING ENGINEER

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This is the first of a series of papers dealing with mining methods and costs in the metal mines of the United States. These papers are being prepared by officials and engineers of mining companies, in cooperation with the Bureau of Mines, and in accordance with an outline prepared by the Bureau for the purpose of securing uniform and comparable data. The mimeograph form of publication is necessary in order to avoid delays in issuing the papers.

After a sufficient number of these papers have been secured, it is planned to issue a series of bulletins dealing separately with each mining method and with particular phases of the general subject such as: "Sampling and Estimating," "Exploration and Development," "Comparison of Mining Methods based on Labor Efficiency and Cost Data," "Drilling and Blasting Practice," "Wage, Contract and Bonus Systems in Metal Mines of the United States," "Shaft Sinking Practice," "Underground Transportation," "Mechanical Loading and Hauling," "Underground Mine Support" and "Ventilation in Deep Mines."

It is hoped that as these papers are published, a number of mining companies will be stimulated to volunteer papers dealing with their own operations for the benefit of the industry as a whole.

Scott Turner

SCOTT TURNER,
Director.

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METHOD AND COST OF MINING MAGNETITE IN THE MINEVILLE DISTRICT, NEW YORK [1]

By A. M. Cummings[2]

INTRODUCTION

Each mining district presents different problems as to the methods of ore extraction and underground support, which are dependent upon the type of the ore deposit and the character of the inclosing rock. Mining costs, however, depend largely upon the efficiency with which the methods employed underground are applied as well as upon the selection of the method best adapted to the physical conditions.

The purpose of this paper is to present to the operator in other districts a detailed description of the mining method used and results obtained in the exploitation of the bedded magnetite deposits of the Mineville district. The town of Mineville is situated in the Adirondacks, five miles west of Port Henry on Lake Champlain.

HISTORY

Records show that iron ore was produced in the Mineville district during the American Revolution. As far back as 1849 Witherbee, Sherman and Co., owners of the present mines, started operations which have been continuous with but small periods of suspension up to the present time. The relative importance of the district is indicated by its vast production, which has amounted to approximately 45,000,000 tons.

GEOLOGY

As shown on the Adirondack sheet of the geological map of New York State, the Mineville district is situated within the area of Adirondack gneisses and Grenville limestone. This area is penetrated by small masses of an intrusive rock (gabbro), and the principal ore bodies are adjacent to one of these masses. Both to the north and west is an extensive mass of gabbro which measures 100 miles across in an east and west direction. The gneissoid rocks are classified as pre-Cambrian, and the occurrence of limestone would indicate that they are of

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2 Consulting engineer, U. S. Bureau of Mines.

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sedimentary origin. Trap dikes occur, crosscutting the gneissoid rocks as well as the magnetite beds. Faults and much folding are prominently disclosed in the underground workings.

ORE DEPOSITS

The magnetite deposits occur interstratified in the gneissoid beds, and the principal ones dip to the southwest at angles of 20 to 30° from the horizontal. They extend from several hundred to several thousand feet in depth and have corresponding lateral dimensions. In thickness they vary from 3 to 40 feet, the average being 10 feet of workable ore.

At the Old Bed mine an important magnetite mass which occurred near the surface averaged over two hundred feet in thickness and is known as the Joker-Bonanza and Twenty-One ore body. This has been mined out except for the pillars left as supports. The ore body is shown in Figure 1, a section through the main hoisting shaft of the Old Bed mine. In places there is no definite division between ore and rock, and magnetite is found disseminated through the gneissoid beds in scattered grains, locally in sufficient quantity to make ore. In other places, and in particular along the footwall, there is a sharp division line separating the ore from the rock.

Ore is mined running as low as 25 per cent Fe and is mixed with richer ores running as high as 69 per cent Fe to produce an average grade of ore mined of 42 per cent Fe. This crude ore is concentrated by magnetic methods to produce a shipping product which will average 68 per cent in iron. The beds have been disturbed by several major and minor faults and have been displaced from 15 to 150 feet; these faults, together with the folding, have added greatly to the difficulty of mining and transportation of ore underground.

EXPLORATION

As certain of the magnetite deposits are exposed along the surface, they have not been difficult to discover. However, to explore the deposits at depth and to locate other deposits which are now being worked, magnetic surveys were made and diamond-drill explorations based on the surveys were carried out extensively.

Records and diamond drill cores were carefully kept. Over a hundred thousand feet of diamond drilling has been done on contract on the Witherbee, Sherman Co.'s property along. According to the record for the years 1918 to 1919, the total footage drilled was 31,725 feet at a total cost of $124,578, or of $3.92 per foot. The diameter of the drill core is 1 inch, and an average speed of 10 feet per eight-hour shift was made.

Geophysical methods based on electrical induction have been tried out this year by the physicists of the U. S. Bureau of Mines. Their results were found to check very closely with those of the diamond-drill records.

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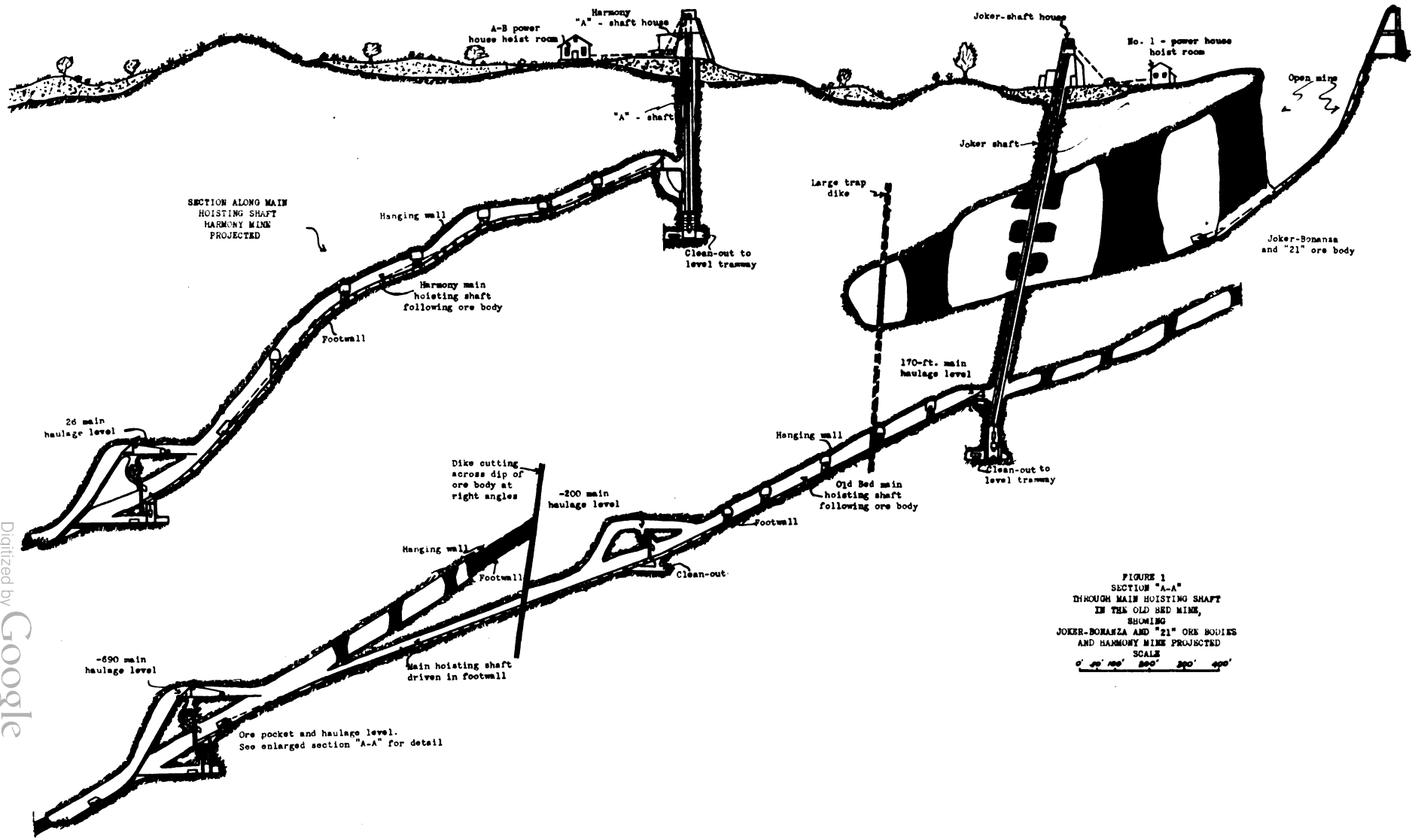

FIGURE 1
SECTION "A-A"
THROUGH MAIN HOISTING SHAFT
IN THE OLD BED MINE,
SHOWING
JOKER-BONANZA AND "21" ORE BODIES
AND HARMONY MINE PROJECTED
SCALE
0' 50' 100' 200' 300' 400'

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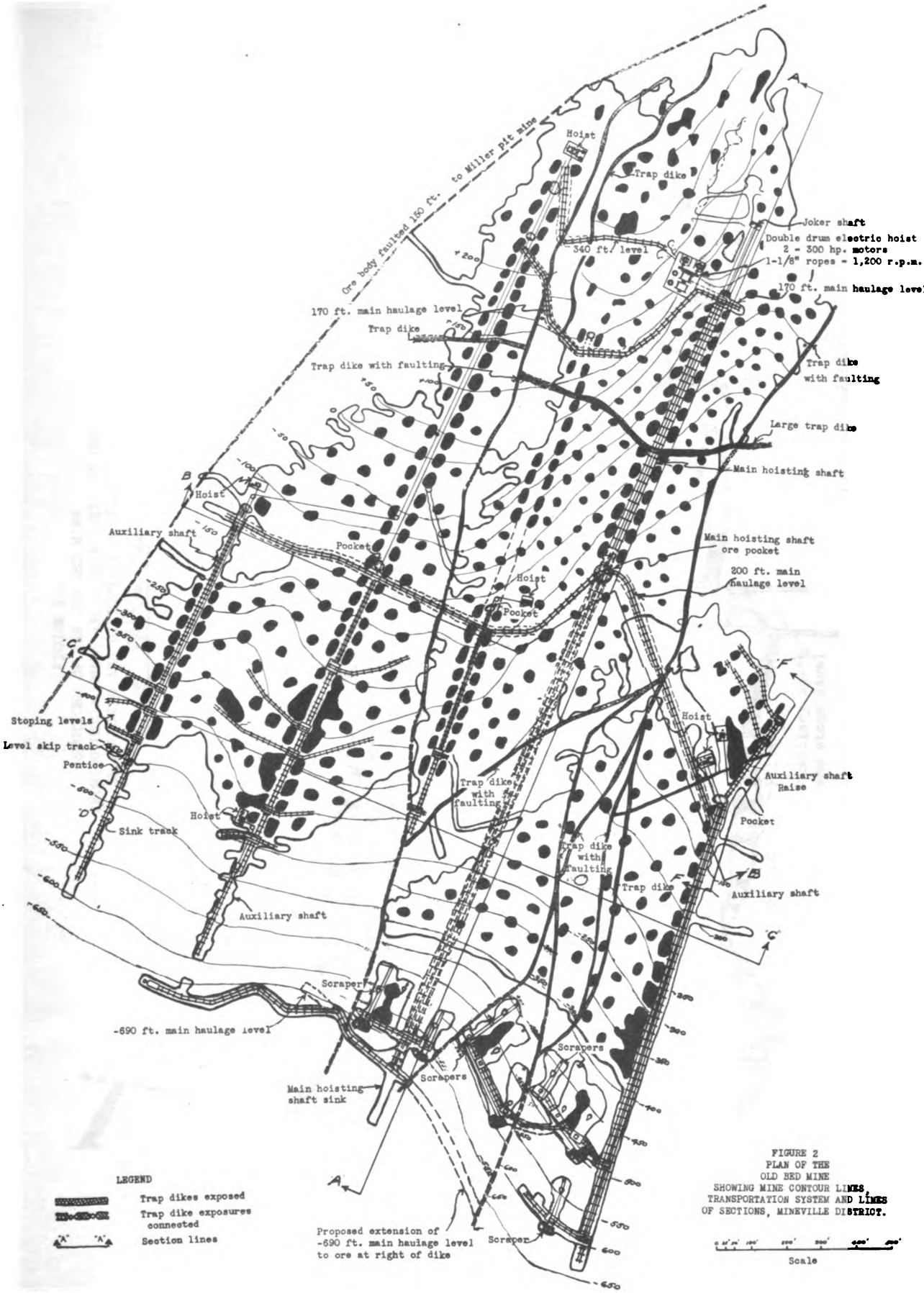

FIGURE 2
PLAN OF THE
OLD BED MINE
SHOWING MINE CONTOUR LINES,
TRANSPORTATION SYSTEM AND LINES
OF SECTIONS, MINEVILLE DISTRICT.

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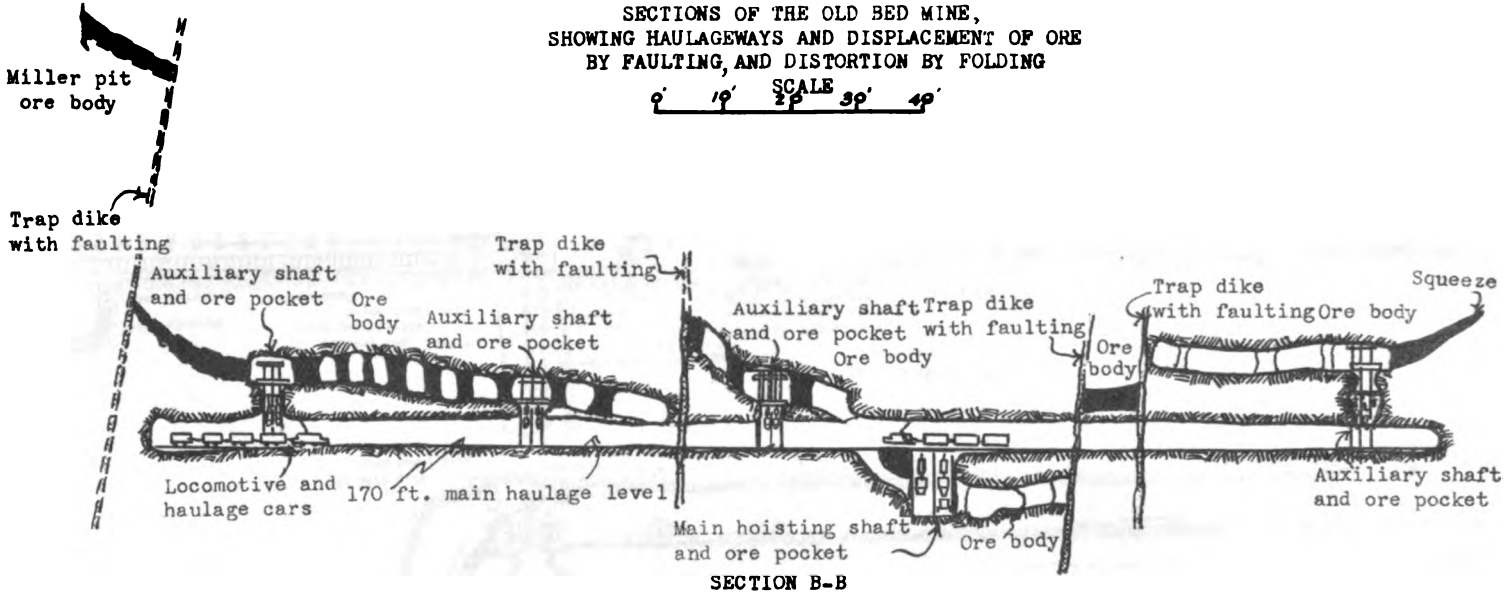
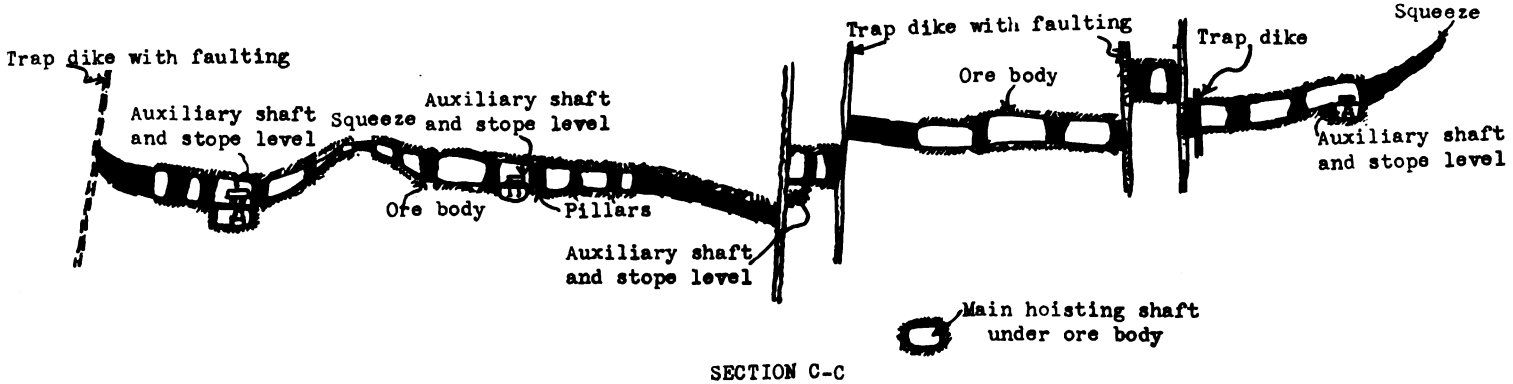
FIGURE 2-A
SECTIONS OF THE OLD BED MINE,
SHOWING HAULAGEWAYS AND DISPLACEMENT OF ORE
BY FAULTING, AND DISTORTION BY FOLDING
SCALE
0' 10' 20' 30' 40'



SECTION B-B
170 FT. MAIN HAULAGE LEVEL



SECTION C-C

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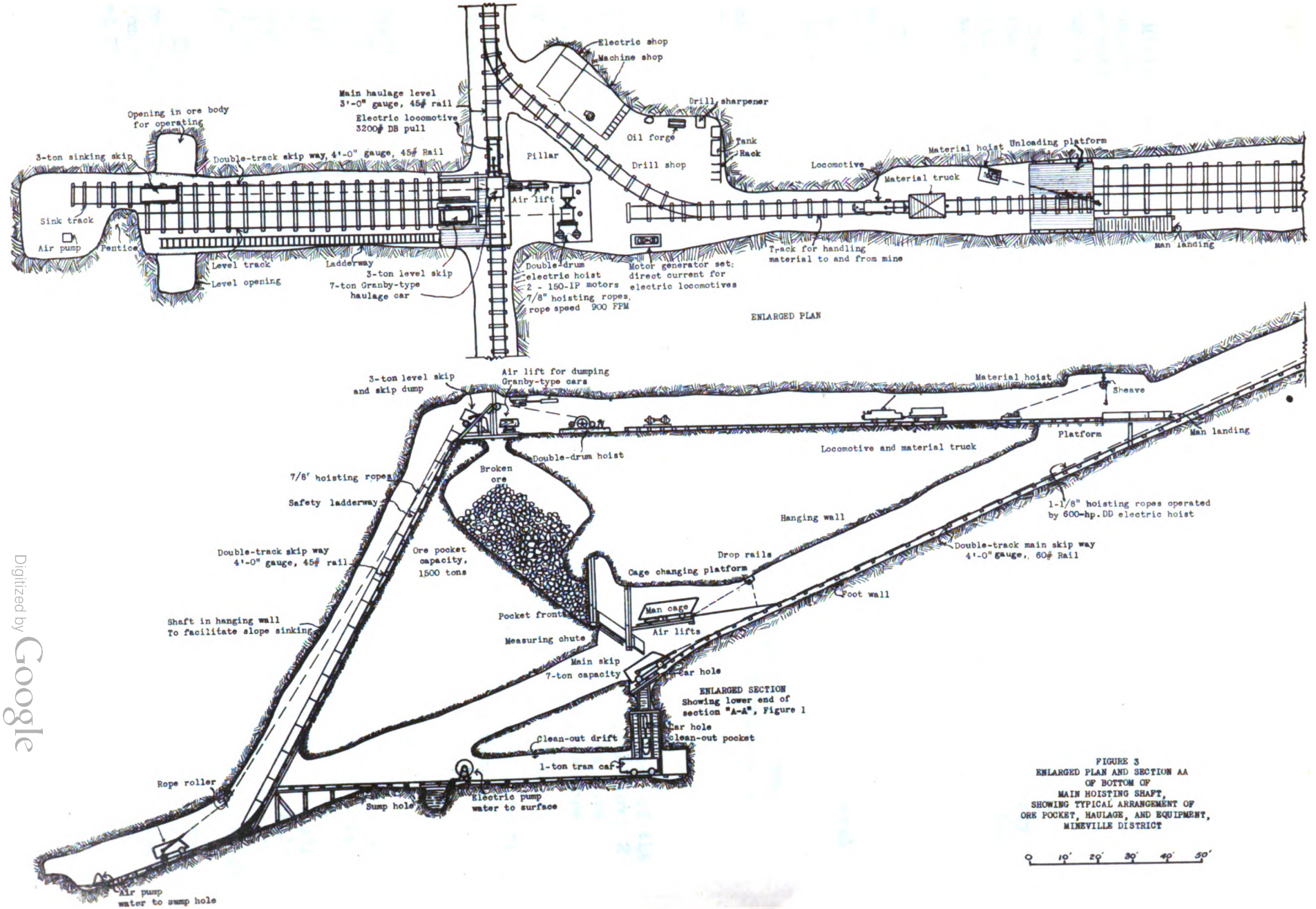

FIGURE 3
ENLARGED PLAN AND SECTION AA
OF BOTTOM OF
MAIN HOISTING SHAFT,
SHOWING TYPICAL ARRANGEMENT OF
ORE POCKET, HAULAGE, AND EQUIPMENT,
MINEVILLE DISTRICT

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EARLY MINING METHODS

Mining was naturally started at the surface and then, due to the flatness of the deposits, inclined shafts were sunk along the footwall of the ore body. From the shafts, working levels were driven in the ore, and the whole area, excepting the pillars left for support, was then mined.

The faulted and folded condition of the ore body made it necessary to change the course of the inclines, which made track maintenance and hoisting very difficult. The result was that as soon as any appreciable depth was obtained, the output was decreased with an attendant increase in cost of production per ton of ore.

The early method of mining included hand-drilling, shoveling, and hand-tramming with wheelbarrows; these operations have been largely replaced by the use of hand tram cars, air drills, scrapers, mechanical loaders, electric shovels, larger mine cars, and electric haulage equipment, thus keeping it with the general mining practice throughout the United States.

The mining method, the open-stope system with pillar support, has remained the same, and it is doubtful if any other system would give as good results under the conditions.

DEVELOPMENT SYSTEM

The development system is simple and relatively inexpensive, as most of the work is in the ore or just under the ore body. This is clearly shown in Figures 2 and 2A, showing a plan and sections of the Old Bed mine. Different scales have been used in the figures in order to show some of the important conditions more clearly.

The following description of the development system will be confined to the Old Bed mine. In the section, Figure 1, the main shaft of the Harmony mine is shown.

Main Shaft

The main shaft follows the dip of the magnetite bed along the footwall, and pockets and loading chutes are placed either in the ore body above or in the hanging wall (fig. 3). A part of this shaft, however, is in the footwall for a considerable distance; this was necessitated by the faulted condition of the ore body at almost right angles to the dip. The general practice is to keep the main shaft as well as the auxiliary shafts along the footwall, cutting into the rock approximately 7 feet to allow each level to start directly on the footwall of the ore body.

The main shaft is generally carried 15 by 20 feet in cross section. When the ore body is not thick enough to attain 15 feet in height, additional rock is cut from the roof. In the rock and where the ore body is small and the levels are located 75 feet apart, the shaft is carried 10 by 20 feet.

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The work in main shafts is carried along with the regular mining operations and the shaft men are paid by the premium system, which will be described later.

The footage per shift in the 10 by 20 foot shafts depends on the speed it is necessary to make. Heavy Leyner-type drills with an air pressure of 85 pounds are used, and each drill is operated by one man. One and one-fourth-inch hollow, round drill steel with cross bits having a taper of 14° and 1/4 inch difference in gauge is employed, and four changes of steel are used. The holes start at 2 1/4 inch and bottom at 1 1/2 inch. The blasting is done with 40 per cent gelatin powder which is detonated by the use of double tape fuse on a No. 6 cap. When speed is required, three drills of the heavy Leyner type mounted on bars and tripods are used. An average of 5 feet per shift is made, using the cuts as shown in Figure 4.

The average cost per foot for sinking, hoisting material to the main shaft, and equipping with tracks, air, and water lines is $32.30 per foot, made up as follows: (1) Drilling and blasting $13.10; (2) mucking and hoisting, $12.40; (3) track, air, and water lines, $4; and (4) miscellaneous, $2.80. One hundred and fifty pounds of powder is used per round. The day is divided into three 8-hour shifts; the drilling is done on one 8-hour shift, and the cleaning by hand on the two remaining shifts.

The experience is that with the present-day drilling equipment the whole problem in making speed in shaft-sinking is that of the removal of the material after it is broken.

In the ore body these shafts are worked in a similar manner to the auxiliary shafts. The sinking is done by stoping out the ore with light hammer drills mounted on tripods (see Figs. 6 and 7). The shafts are timbered only at the loading stations.

Main Haulage Levels

Extending from the main shaft, at intervals of 1,000 to 1,500 feet along the dip, are the main haulage levels; these are 15 by 10 feet, with enlargements for switches and ore pockets, and are driven in the footwall on a contour which will keep them near the ore body and require the minimum amount of rock work to connect the the faulted area. From the levels crosscuts and raises are driven to the ore body in each faulted area and at intervals in the unfaulted area where a single auxiliary shaft would make the length of tramming too great. The raises are driven to permit the introduction of small ore pockets; the crosscuts are driven to give easy access to the auxiliary shaft for the transportation of men and supplies. On the main haulage level the ore pockets have timbered fronts on which are installed mechanically operated chute doors. The driving of the haulage levels from the main and auxiliary shafts is carried along with the regular mining operation and under the same premium system.

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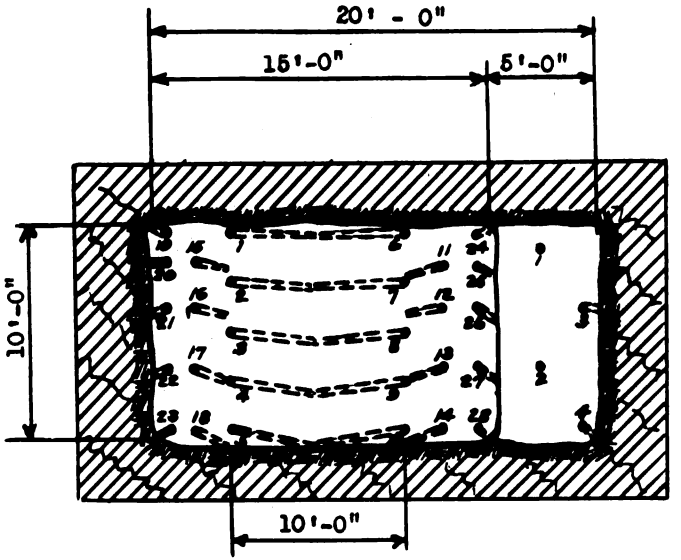
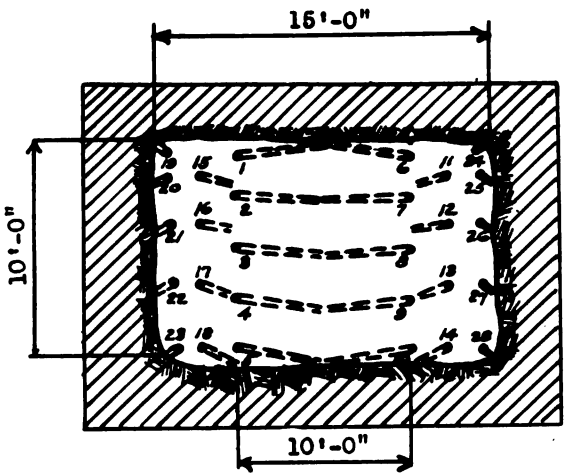
FIGURE 4
DRILL ROUND
IN
SHAFTS

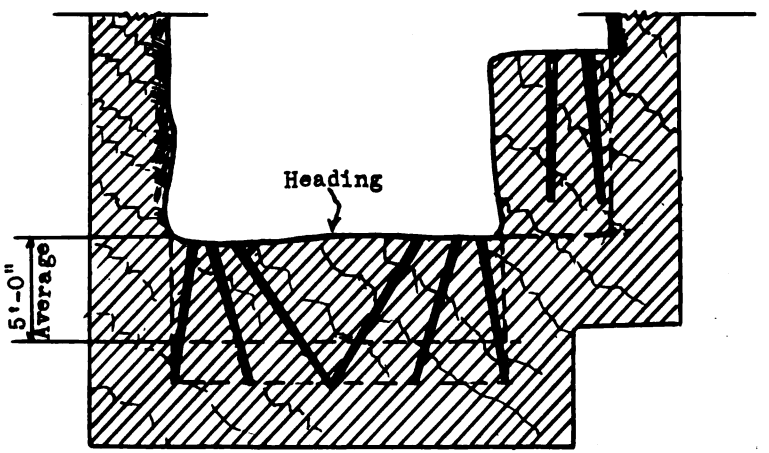


SECTION
NORMAL TO SLOPE

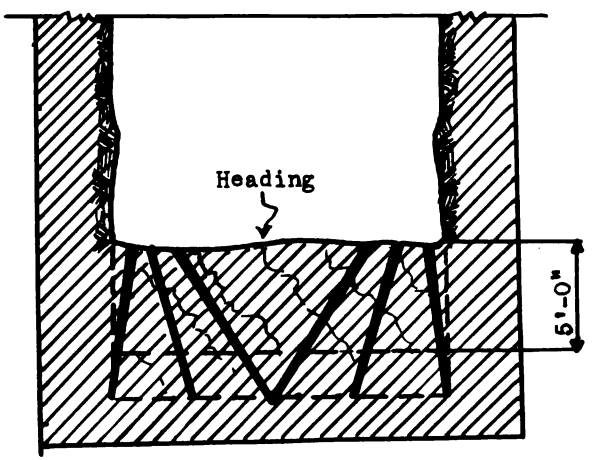
FIGURE 5
DRILL ROUND
IN
DRIFTS



VERTICAL SECTION OF DRIFT



SECTION PARALLEL
TO SHAFT



HORIZONTAL SECTION OF DRIFT

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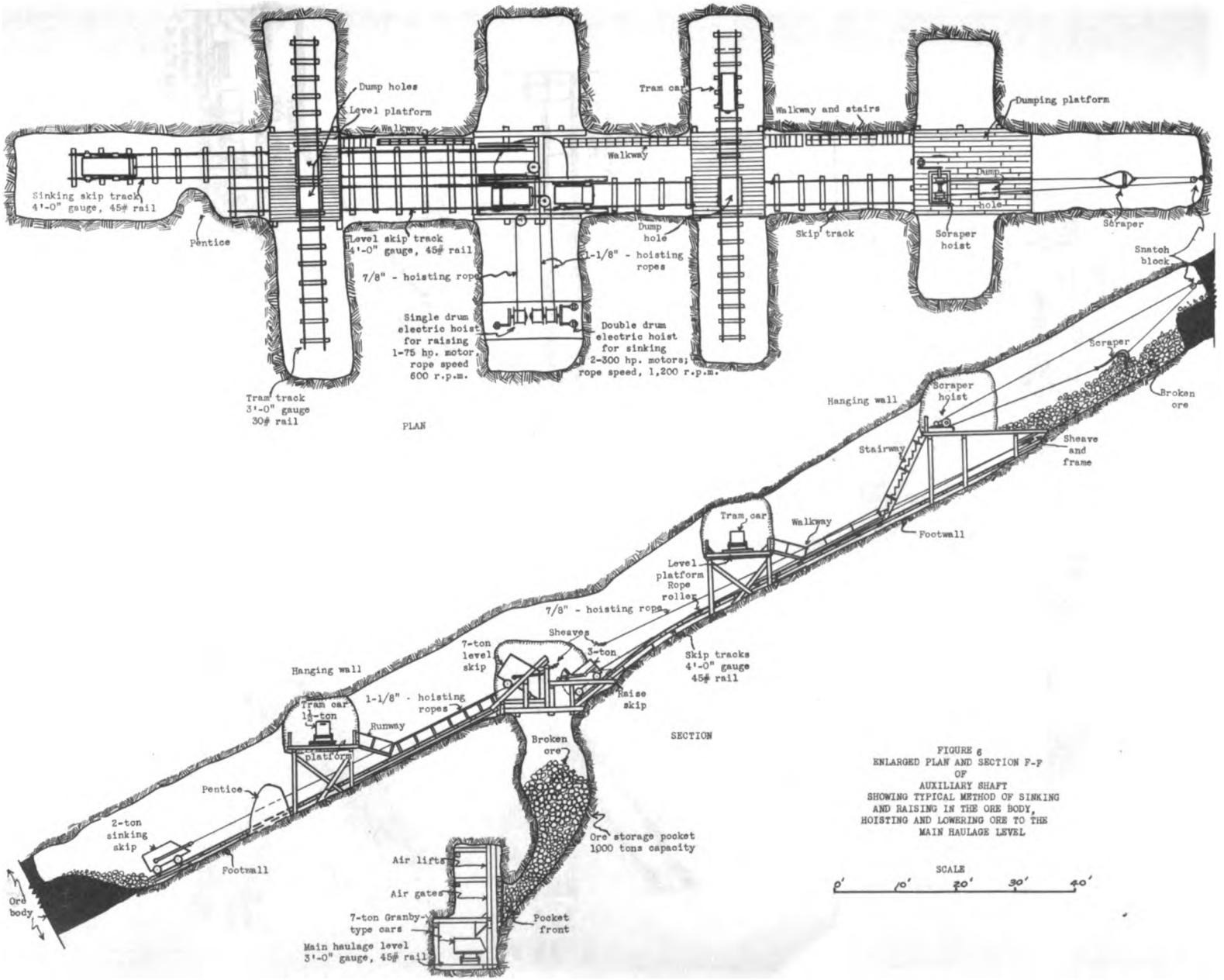

FIGURE 6
ENLARGED PLAN AND SECTION F-F
OF
AUXILIARY SHAFT
SHOWING TYPICAL METHOD OF SINKING
AND RAISING IN THE ORE BODY,
HOISTING AND LOWERING ORE TO THE
MAIN HAULAGE LEVEL

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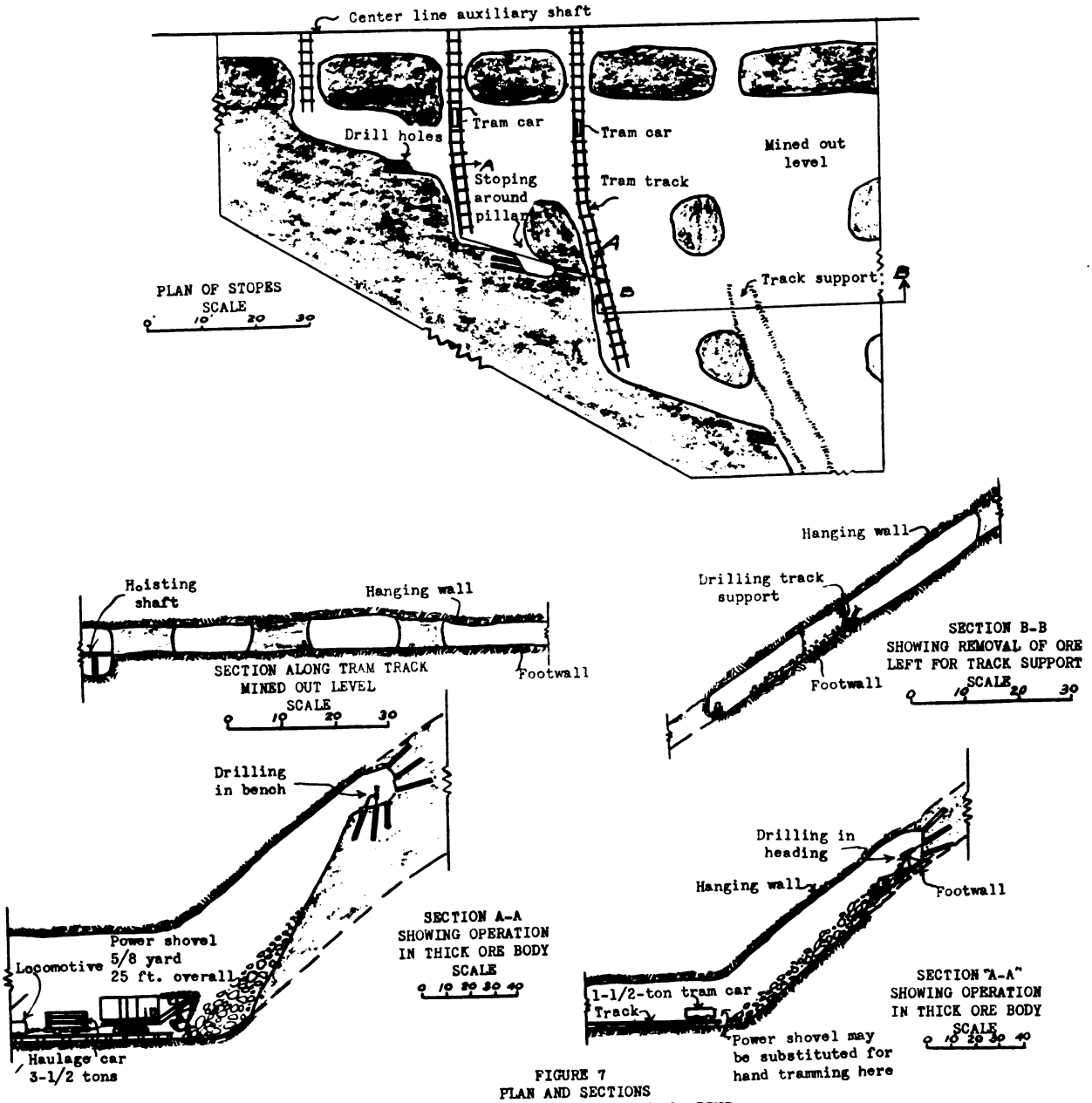

FIGURE 7
PLAN AND SECTIONS
SHOWING METHOD OF STOPING AND LOADING
IN VARYING THICKNESSES OF ORE BODY
MINEVILLE DISTRICT

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Two drills of the heavy Leyner type, each operating on a single screw column and equipped as for shaft-sinking, are used in driving the drifts. An average advance of 5 feet per shift is obtained. Some of the records show an advance of 7 feet per round for a distance of 600 feet. The whole operation is carried on in a single eight-hour shift. The drillers are able to drill a round and blast in five and a half hours. The material is then removed in three hours with mechanical mucking machines served by an electric locomotive. Four men are engaged in the work - two on the drills, one on the shovel, and one on the locomotive. The men on the locomotive and shovel are employed at other parts of the mine during the remaining part of the eight-hour shift. An average of 125 pounds of 40 per cent gelatin powder is used per round, or 25 pounds per foot. Figure 5 shows the form of cut used. The average cost of driving, tramming material to main shaft pocket, and equipping with tracks, electric power, air, and water lines is $15.46 per foot, made up as follows: (1) Drilling and blasting, $7.66; (2) mucking and tramming, $4.60; (3) track, air, electric power, and water lines, $1.80; (4) miscellaneous, $1.40. In this operation approximately 50 tons of material can be removed with the mechanical shovel in three hours.

Tests are now being conducted with the latest models of heavy Leyner-type drills offered by several manufacturers. Some of these drills have proved that they can make at least 25 per cent greater drilling speed than the older models now in general use in these mines. Their performance indicates the improvement in rock-drill design in recent years.

With the use of faster cutting drills and mechanical shovels it may be possible for two men to completely drill, blast, and remove the material from a haulage drift in eight hours.

Auxiliary Shafts

One or more auxiliary shafts are located in each faulted area, and are driven both up and down the dip of the ore body, starting at the top of the ore pocket on the main haulage level. When the main shaft is in the ore body, the extension is operated as an auxiliary shaft until a new station is cut and a connection is made with the main shaft. The ore from the stoping levels is delivered to the auxiliary shafts and is hoisted or lowered to the loading pocket on the main haulage level or to the main shaft pockets.

Auxiliary shafts are carried 7 feet in the footwall to the full height of the ore body and are made 20 feet wide. They are sunk or raised by carrying breast headings 7 feet high at the hanging wall and underhand-stoping the remaining material. When a shaft is being extended in depth a double track is used. One car hoists from the levels and the other car hoists directly from the sink. This procedure is continued until the distance from the sink to the ore pocket on the haulage level becomes approximately 800 feet, at which point a small ore pocket is installed to discharge the material into the car which is hauling from the levels. An ore or rock pentice is left back of the operating track to protect the men working in the sinks.

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In advancing the auxiliary shafts up the dip of the ore body the material is removed by scrapers which carry the material directly onto a platform. When a carload of material has been collected on the platform and it is pulled into a skip car, as soon as a car can be spared from the levels without causing delay. Figure 6 illustrates the method of advancing these shafts.

The work which is charged to the development account includes the sinking and cutting out for ore pockets along the main haulage shaft and main haulage level, and the exploration sinks and drifts in the auxiliary shafts. All the work in connection with sinking, cutting out levels, installing tracks, platforms, air, water, and power lines, etc., along auxiliary shafts is charged to the regular mining account.

PRESENT MINING METHOD

The plan and sections of the Old Bed mine workings (figs. 2 and 2A) show the general system of mining in the district. Starting from the auxiliary shafts, stoping levels are advanced at intervals of from 30 to 100 feet, depending upon the dip, width, and faulted or folded conditions of the ore body. Figures 7 and 8 show the methods employed, with variations which depend upon the condition of the ore body.

The upper levels are kept well in advance of those below so as to get the greatest benefit from gravity and the minimum amount of heading work. Where the bed is 15 feet thick, headings are continued at a height of 7 feet until a break is made to the upper level. These headings and the upper levels form a bench from which underhand-stoping is done. Figure 7 shows the method of stoping where the loading is by hand and mechanical shovels. Figure 8 shows the method of stoping where scrapers are used.

The magnetite breaks very large, and it is necessary to do a great deal of blockholing. Small holes are drilled in the slabs which are broken up by the use of portions of a stick of powder.

All the work in the auxiliary shafts, including the shaft sinking and the small amount of drifting necessary, is performed with mounted and unmounted light hammer drills operated either wet or dry as the conditions may require.

The light hammer drills are mounted only when used in the headings and drifts. For the underhand work they are operated by hand. In stoping 1 ton of ore, an average of .779 pounds of powder is used. Twenty-five per cent powder is used in all auxiliary shaft work. Forty per cent gelatin is used in the rock work in the main shaft and the main haulage level. Approximately 75 per cent of the 40 per cent grade and 25 per cent of the 25 per cent grade of powder is used. The cost of the 25 per cent powder for the year averaged $0.1375 per pound and the 40 per cent powder $0.1525 per pound.

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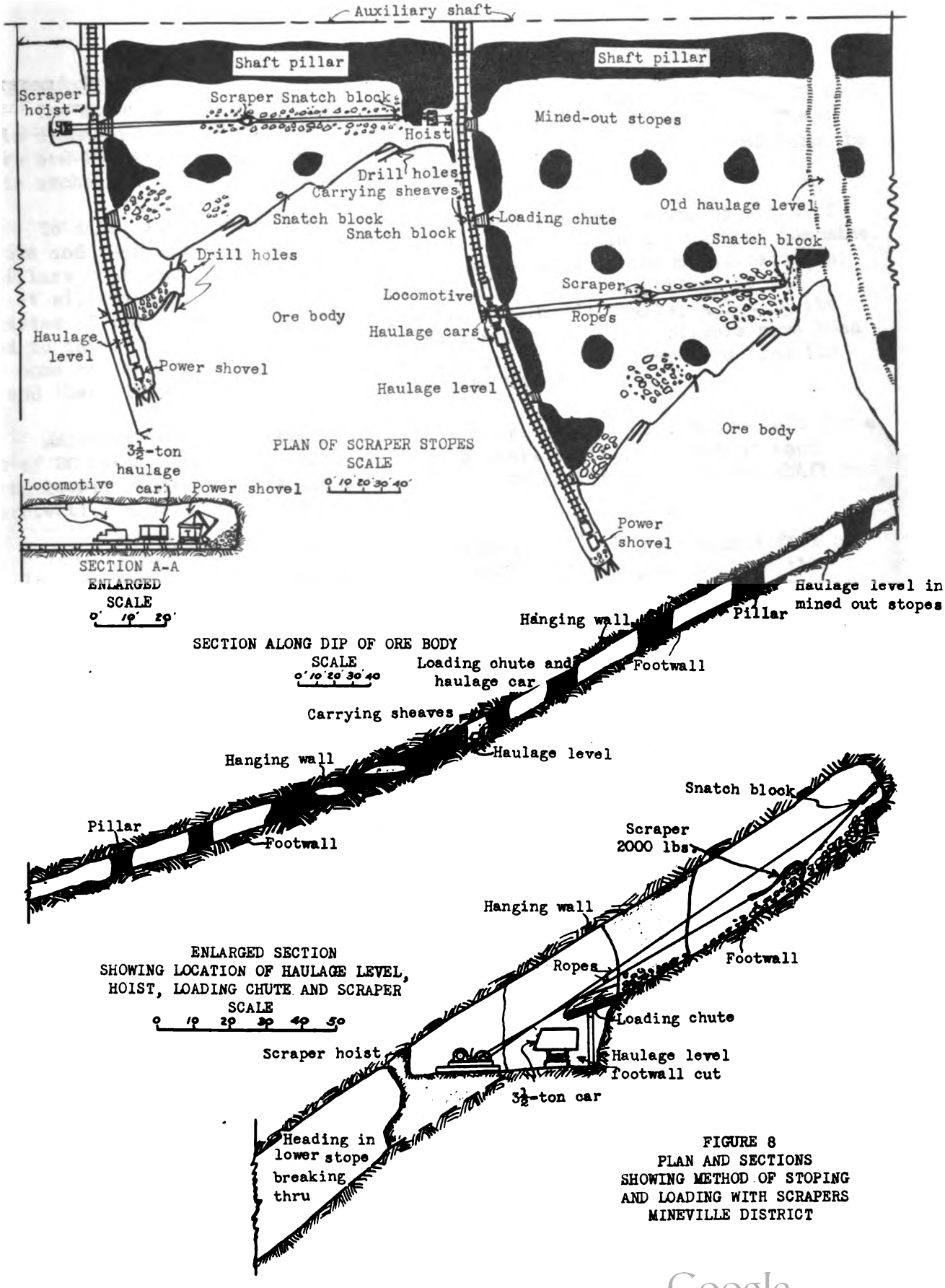

FIGURE 8
PLAN AND SECTIONS
SHOWING METHOD OF STOPING
AND LOADING WITH SCRAPERS
MINEVILLE DISTRICT

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Underground Support

The mine is supported entirely by pillars of ore which vary from 20 to 60 feet in diameter, depending upon the height and character of the roof. These pillars are spaced about 50 feet from center to center. Between the pillars the roof is arched to prevent slabbing off of the ore or rock.

To date, even on the lowest levels the pillars have shown no signs of pressure and there has been no breaking down of the roof in any part of the mine. The pillars represent 25 per cent of the magnetite beds in the mined sections; later it will be possible to recover this ore by mining the pillars at the boundaries of the mine or body and retreating toward the shafts, allowing the ground to cave. In certain of the upper workings where large pillars have been left, some of the pillars have been mined by first cutting them free from the roof and then blasting them down with underhand holes.

Adjacent to the auxiliary and main shafts, pillars of ore are left for a width of 20 feet on each side through which a small drift is driven at each stoping level. These pillars are left not only to give support to the shaft but for protection against mining in the stopes.

Fault planes occur which sometimes displace the beds a hundred feet or more, locally making additional support necessary. The displacement of the magnetite beds prevents a regular development of the mine, and additional shafts and connections with the main haulage levels have often been made necessary thereby.

DRILLING AND BLASTING PRACTICE

Compressors:

The air compressors range in capacity from 300 cubic feet per minute to 5,600 cubic feet per minute. All of these compressors excepting the 300 cubic-foot machines are located on the surface in central plants. The 300 cubic-foot machines are installed underground and are used when a small amount of air is required for work between shifts.

Drills:

Nearly all makes of drills are in use in the Mineville district. With few exceptions, they are operated as one-man machines. The heavier drills are used in the main shafts and main haulage roads and are operated on tripods, columns, and bars. They are equipped to use 1 1/4-inch round, hollow drill steel.

The light drills are used in all the auxiliary shafts, stoping levels, and small drifts and are equipped to operate dry or with water, as occasion demands. They are operated on columns, tripods, and by hand. A cradle is used to hold the machine in the shell and is so designed as to allow the machine to operate with

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the hose connection on the outside, away from the face, which allows them to be run near the sidewall thereby allowing a good burden on the top of the hole. These machines are equipped for the use of 7/8-inch hexagon, hollow drill steel.

Both the 1 1/4-inch steel and 7/8-inch steel are made up with cross bits, have a 14° taper and a 1/4-inch difference in gauge. Four changes of steel are used and holes up to 10 feet in depth are drilled. The holes are started at 2 1/4-inch gauge with the 1 1/4-inch steel and bottomed at 1 1/2-inch gauge. With the 7/8-inch steel, the holes are started at 2-inch gauge and bottomed at 1 1/4-inch gauge. The shanks used are of the standard lug type. These steels are bitted and shanked on sharpening machines located underground on the main haulage levels.

Compressed Air.- No meter records are available giving the air consumption per ton for drilling. The air-compressor account includes the air used for operating pockets and chute doors, air hoists, pumping, etc., and that used on the surface about the mills and shops. The total cost is 10 cents per ton of ore hoisted.

The steel consumption in 1927 was .125 pound per ton of ore, of which 10 per cent was 1 1/4-inch round hollow, and 90 per cent 7/8-inch hexagon hollow.

LOADING AND TRAMMING

Tramming in the auxiliary shafts is by hand-pushed tram cars with a capacity of 1 1/2 tons of ore, and by haulage cars with a capacity of 3 1/2 tons of ore. The haulage cars are drawn by electric locomotives of the trolley type.

The hand tram car, which is very low (2 ft. 7 in. above rails), is used when the loading is done by hand. The haulage cars are high (4 ft. 5 in. above the rails), and are loaded by power shovels or with scrapers.

The mechanical loading is a problem on which much time and money have been spent. The problem has by no means been completely solved, but the present conclusion is that a combination of the scraper and small air-operated shovels is best suited to these deposits.

In arriving at this conclusion, factors other than the actual loading of the material have been taken into consideration, such as the effect on cost of stoping, the amount of money tied up in development work, and the crude content and faulted condition of the deposit.

The scraper hoist of the clutch type with planetary transmission, operated by 25-horsepower direct-current motor, has proved the most satisfactory hoist to date. Direct current as applied in haulage locomotive motors is found to be more efficient for this kind of load than the alternating current. If the voltage on the scraper hoist motor is made the same as the voltage on the haulage locomotive motor, no extra line will be required. The scraper motor can be operated by simply connecting it to the rail and trolley wire; as most scrapers are served by a haulage locomotive, this is very important. Scrapers of the hoe type are employed exclusively.

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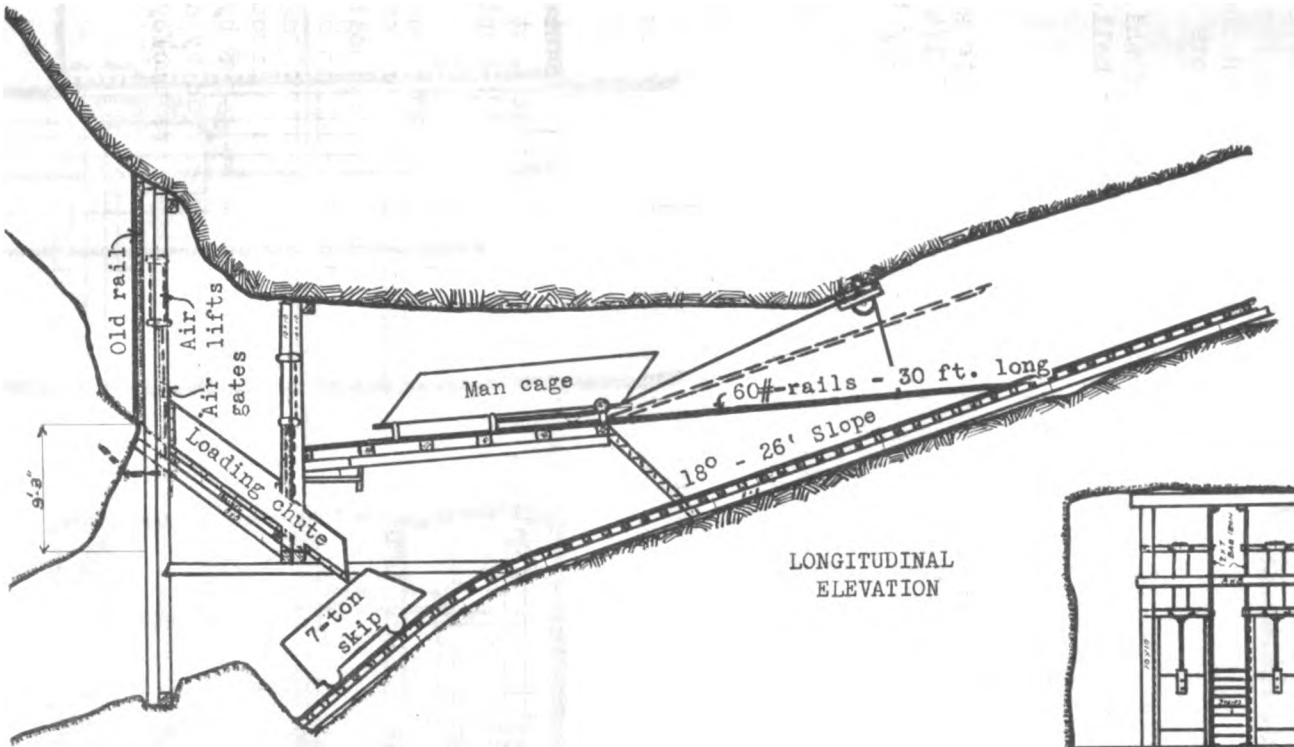
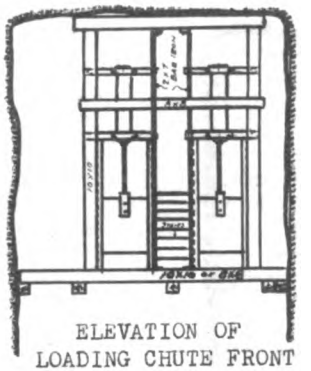
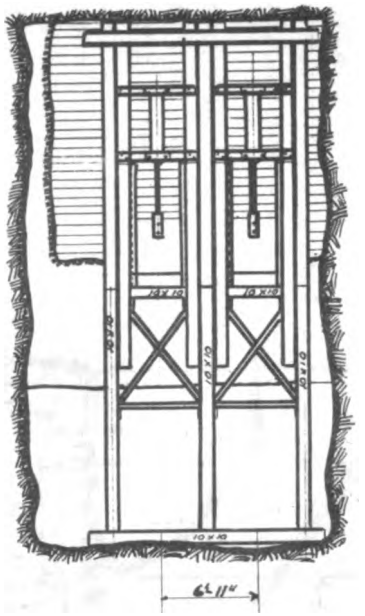


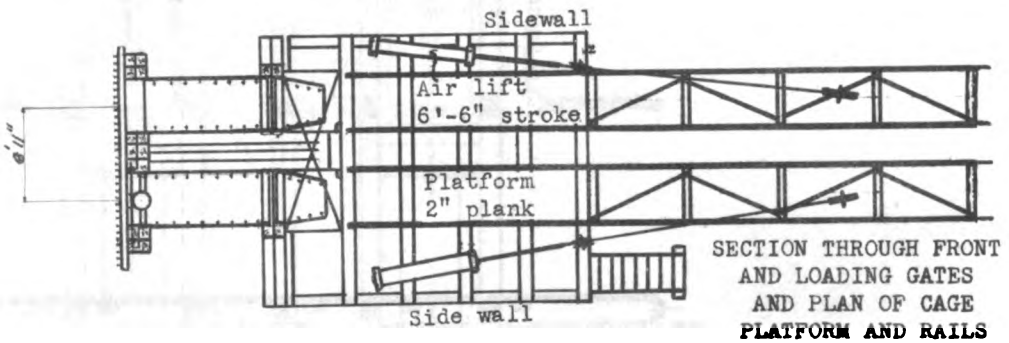
LONGITUDINAL ELEVATION



ELEVATION OF LOADING CHUTE FRONT



FRONT ELEVATION



SECTION THROUGH FRONT AND LOADING GATES AND PLAN OF CAGE PLATFORM AND RAILS

BILL OF MATERIAL

4 - Air gates - with guides
4 - Air lifts - 4'-0" lift
2 - Air lifts - 6'-6" lift
2 - Loading chutes 3'-0" high
2 - Lip chutes
4 - 8" sheaves
2 - Throw rails
65 ft. - 1/2" or 5/8" wire rope
36 - Old rails - pocket front
8 - Hangers - for air lifts
6" x 6", 8" x 8", 10" x 10" timber plank for platforms

FIGURE 9
POCKET, GATES, AND CAGE PLATFORM

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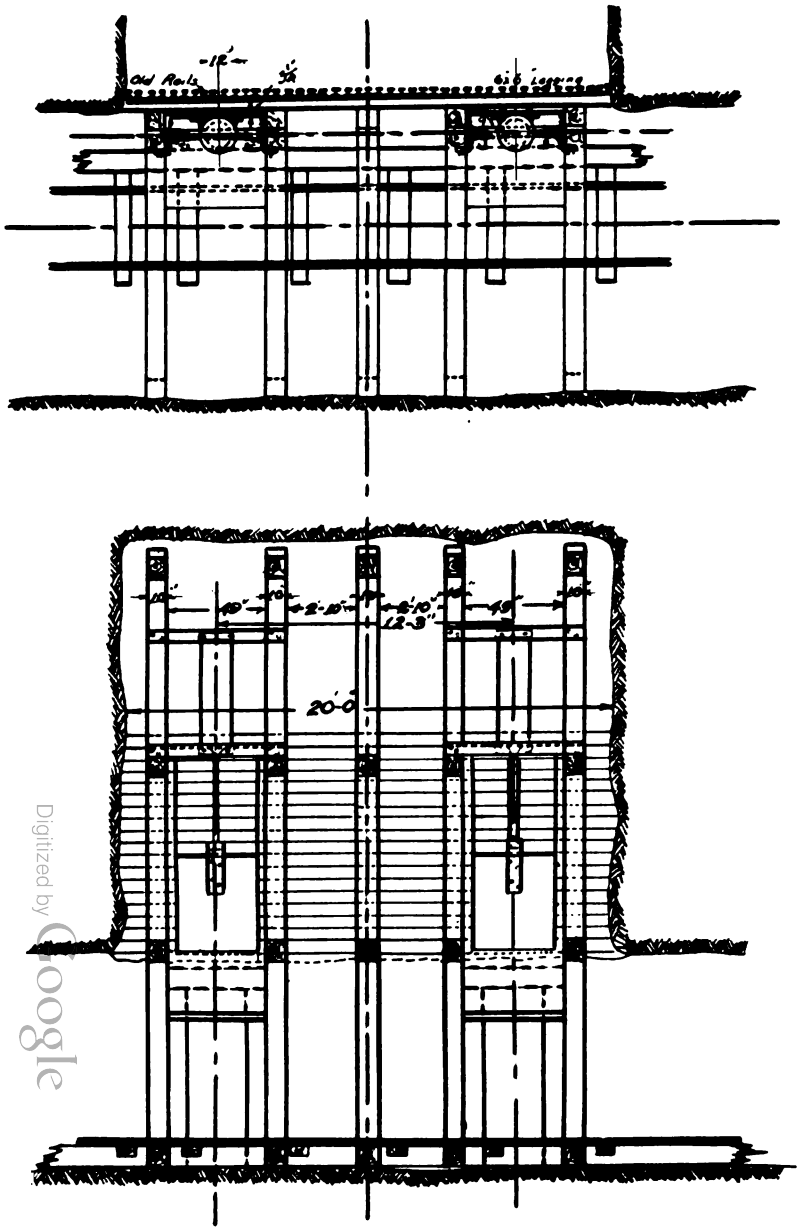

FIGURE 10
STANDARD FRONT
FOR UNDERGROUND
ORE POCKETS

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Air-driven shovels of the dipper type have proved more satisfactory in this work than the electrically driven machines. They have a lower first cost, smaller upkeep, will handle an equal amount of material per shift, and are easy to transfer from one working place to another. The air consumption with the air-driven shovel is high, giving a higher power cost per ton loaded. When it is considered, however, that the shovel is operated in unventilated places and often directly after blasting in a drift, the benefit of the exhaust air for ventilation may offset the lower power consumption of the electrically operated type.

As compared to scrapers, the shovels have a higher first cost and higher power consumption. They have the advantages, however, of working better in a drift and of being suitable to replace hand-loading in most places on the levels without changing the mining method. The total loading cost is about the same with the shovels as with the scrapers and in either case, is dependent on the quantity of broken material available. There is no increase in the stoping cost.

The electrically driven shovel shown in Figure 7 will operate in a space 15 feet wide and has proved to be the most satisfactory loading device where the ore body over a considerable area is large enough to give it operating room.

Ore Chutes

Figure 9 gives the details of a typical ore chute and door arrangement at a pocket on the main shaft. Figure 10 shows the door and chute at the pocket on the main haulage road.

Electric Locomotives

The electric locomotives in use are all of the trolley type and range from 1,200 to 3,000 pounds draw-bar pull. The large size is used on the main haulage roads and the smaller size on the levels and drifts from the auxiliary shafts.

Below are the haulage costs per ton mile on one of the main haulage roads for a period of one month. Distances are from main shaft pocket to auxiliary shaft pocket. Tonnage, distance, and labor costs are taken from actual records. Power and supplies are prorated from the total haulage account.

Tons Handled		Length of Haul			
7,591		750	feet	Total ton miles ...	3,080
9,715		800	"	Total cost	$427.00
8,682		1,550	"	Cost per ton mile .	$ .084
Total	25,988	Average	1,032	"	

HOISTING

Due to the number of auxiliary shafts necessary, many hoists are used underground. They are all electrically operated, but are of several different makes and range from 600 hp. with 1,200 feet per minute rope speed, to 22 hp. with 400 feet per minute rope speed.

PUMPING

The mines are comparatively dry, as most of the water comes from the surface. Water is prevented from reaching the lower parts of the mine by being collected in sumps from which it is removed by electric pumps having capacities varying from 100 to 400 gallons per minute. Small air pumps are used in the sinks to take care of the seepage.

LABOR EFFICIENCY, 1927

The record of the tons per drill, tons per man, tons per man tramming, tons mined, etc., at the Harmony and Old Bed mines combined for the year 1927 follows:

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Record of Labor Performed at the Old Bed and Harmony Mines, 1927[1]

	Total shifts for year	Tons per shift
Mining:		
Trammers	35,306	
Runners and helpers	16,866	
Miscellaneous	34,144	
Total underground operations	86,316	8.03
Total drill shifts	16,873	41.06
Development:		
Trammers	4,047	
Runners	2,459	
Drill shifts	2,226	
Total underground labor	92,822	7.46
Total drill shifts	19,099	36.27
Total trammers	39,353	17.60

1 Ore hoisted at Old Bed and Harmony mines during 1927 amounted to 692,726 tons.

Figure 11 is a mine daily report of underground operations for December 31, 1927, and shows the results for the month of December, and the year 1927.

WAGE, BONUS AND CONTRACT SYSTEM

At the Witherbee, Sherman and Co.'s mines the wage is based on an hourly rate.

For 1927 the schedule as applied to the important classifications was as follows:

Trammers	$0.32 per hour
Drill runners	.36 do.
Hoist men and locomotive operators	.34 do.
Carpenters and repair men	.40 do.
Foreman and roof man	.41 do.
Shift foreman	.45 do.

A premium is paid all classes of labor. This premium is based on the hand cars loaded and trammed and the tons broken per man drilling.

Tramming.- Twenty-eight cents per car is paid to the men who load and tram 10 cars per shift, 29 cents per car for 11 cars and 30 cents per car for 12 cars and over. Men tramming less than 10 cars per shift receive the base rate of 32 cents per hour or $2.56 per shift.

The tram cars have a capacity of 1 1/2 tons of the richest ore when completely filled but due to the different grades of ore, an average of 1 ton per car is obtained.

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LOCATION	General	Slope No. 1 Levels	Slope No. 1 Sink	No.3 Levels	No.4 Levels	No.5 Levels	No.6 Levels	No. 8 Levels	No. 8 Sink	No. 9 Levels	No. 9 Sink	No.2 Operat'g	No.2 Total	Total Day Operat'g	Total Day Develop.	Total Day Total	Total Month Operat'g	Total Month Develop.	Total Month Total
General Foreman	1													1		1	26		26
Shift Bosses	1													1		1	26		26
Slope Bosses		1		1	1		1	1		1		1	26	6		6	178		178
Ass't Slope Bosses				1	1		1	1		1				5		5	141		141
Bell Ringers				1	2	2	1	2		1				9		9	228		228
Leyner Machines			2					2						2	2	4	57	136	193
Jack Hammer Machines				2	8	2	4	6	1	5	1			27	2	29	724	40	764
Machine Men			2	2	8	2	4	8	1	5	1			29	4	33	781	176	957
Contract Trammers				4	15	6	10	16		6	2			57	2	59	1514	256	1770
Day Trammers				2						1				3		3	83	4	87
Shovel					2			5						7		7	234	3	237
Brakemen	2	1		2	1	1	1	1		2		1	26	11		11	295		295
Repair and Pump Men	6							2						8		8	118		118
Blasters	1													1		1	26		26
Trainmen	2							1						3		3	91		91
Drill Shop	2													2		2	52		52
Electricians	2													2		2	61		61
Pocket Men	2												5	2		2	52		52
Carpenters	9											12	167	9		9	246		246
Roof Men	1													1		1	22		22
Rope Men and Oiler	1													1		1	26		26
Cage Men																			
Total Men Underground	30	2	2	13	30	11	18	37	1	17	3	14	224	158	6	164	4200	439	4639
No. Cars (Hand)				64	212	108	160	302		95						941			25129
No. Cars (Trolley)								19								19			199
No. Cars (Contract)				64	248	120	172	302		90	48					1044			33534
No. cars (Trolley)Shovel					15			20								35			917
No. Skips Hoisted (Sink)											22					22			2392
Tons by U. G. Cars				64	257	108	160	362		95	44					1090			32664
Tons per Trammer				10.6	15.1	18.0	16.0	17.2		13.5	22.0					22.12			16.78
Tons per Machine Man				32.0	32.1	54.0	40.0	45.2		19.0	44.0					46.24			36.71
Tons per Man				4.92	8.56	9.72	8.89	9.78		5.58	14.6					9.30			7.47
Holes Fired			24	10	52	16	27	64	10	40	10			209	44	253	6400	1758	8158
Powder Used (Sticks)			300	80	420	150	250	550	100	300	100			1750	500	2250	55530	21420	76950
No. Skips Hoisted (Levels)				44	110	72	106	142		50						524			13922
No. Trolley Cars (Haulage)						22	22									44			3389
Main Haulage Skips	155															155			4334
Surface Skips	300															300			8856
Tons by Surface Skips	975															975			28784
Actual Tons																1526			35139
Analysis																			
Ratio																1.32			1.30
Tons per Hand Tram Car																1.40			1.07

REMARKS: Hoisting 8:00 a.m. to 3:45 p.m.

December 31, 1927

FIGURE 11

DAILY REPORT
OF
UNDERGROUND OPERATIONS

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Drilling.- An average of 30 tons per man drilling for a period of one month for all men engaged in drilling is the basis of the drilling premium. Fourteen cents per ton for the average tons per man drilling is paid each man engaged in drilling. When the average of the tons per man drilling falls below 30 tons, the men receive the base rate of 36 cents per hour, or $2.88 per shift.

The difference between the hourly rate of $2.88 per shift for drill runners and the amount earned at 14 cents per ton is the premium. This premium is given to all other classifications, including the mine captains, with the exception of the trammers, in addition to their regular hourly rates.

As far as possible the system described is made to apply to all conditions, but there are exceptions in both tramming and drilling work which make adjustments necessary in order that compensation for the work may be more comparable to the rate for average conditions.

In some of the sinks and long headings, special arrangements are made as to the number of cars required for a day's work. To make their earnings per shift higher extra hours are given the drill runners when in difficult places requiring the most experienced men. Extra hours are also given to those who assist in blasting. The hoist man and electric locomotive operators receive extra hours when the hoisting extends beyond the regular 8-hour shift.

The average wage for all men at Harmony and Old Bed mines for the year 1927 was $5.63 per day.

Figure 12 is a chart showing the tonnage, costs, tons per man, and wages from 1913 to 1927, inclusive. To one with a knowledge of conditions existing at the time, the effect of tonnage and labor conditions on costs and efficiency is plainly shown by this chart for the different years. The factors affecting costs are the character of the ore body, tonnage requirements, cost of labor and supplies, and the amount of money available for equipment and exploration.

MINING COSTS

Below is the mining cost of delivering a ton of ore at the shaft houses on the surface at Witherbee, Sherman and Co.'s Old Bed and Harmony mines combined during the year, 1927. This is the total underground cost with the exception of 6 cents per ton charged to a deferred account which includes equipment for main shaft extension.

Mining Cost of Delivering a Ton of Ore to the Surface[1]

	Labor underground	Supervision labor	Compressors, air drills, drill steel	Electric power	Explosives[2]	Other supplies	Total
Development	.061	.005	.015		.021	.001	.103
Stoping	.164	.014	.113		.122	.003	.416
Tramming	.333	.027		.005		.038	.403
Haulage	.028	.002	.015	.008		.012	.065
Hoisting	.105	.009		.070		.053	.237
Pumping	.007	.000	.012	.004		.003	.026
Total	.698	.057	.155	.087	.143	.110	1.250

1 Ore hoisted at the Old Bed and Harmony mines during 1927 amounted to 692,726 tons

2 Includes caps and fuse.

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Summary of Costs in Units of Labor, Power, and Supplies

Name or number of mine - Old Bed and Harmony ..... Year - 1927

Tons ore mined and hoisted - 692,726

Mining method. (Open stopes with pillar support)

	Development	Mining	Total
A. Labor (man hours per ton)			
Breaking (drilling and blasting)	.028	.236	.264
Timbering			
Mucking	.046	.480	.526
Haulage and hoisting		.193	.193
General			
Pumping		.010	.010
Supervision	.006	.074	.080
Total labor underground	.080	.993	1.073
Average tons per man per shift			7.46
Labor, percentage of total cost	5.28	55.12	60.40
B. Power and supplies			
Explosives (lbs. per ton)	.138	.799	.937
Total power (in kw. hrs. per ton)			10.91
(1) Air compression			5.16
(2) Hoisting			4.64
(3) Pumping			0.26
(4) Ventilation			
(5) Lighting			
(6) Haulage			0.52
(7) Tramming			0.53
Other supplies in percentage of Total supplies and power	0.20	22.02	22.22
Supplies, percentage of total cost	2.96	36.64	39.60
C. Percentage of total cost	8.24	91.76	100.00

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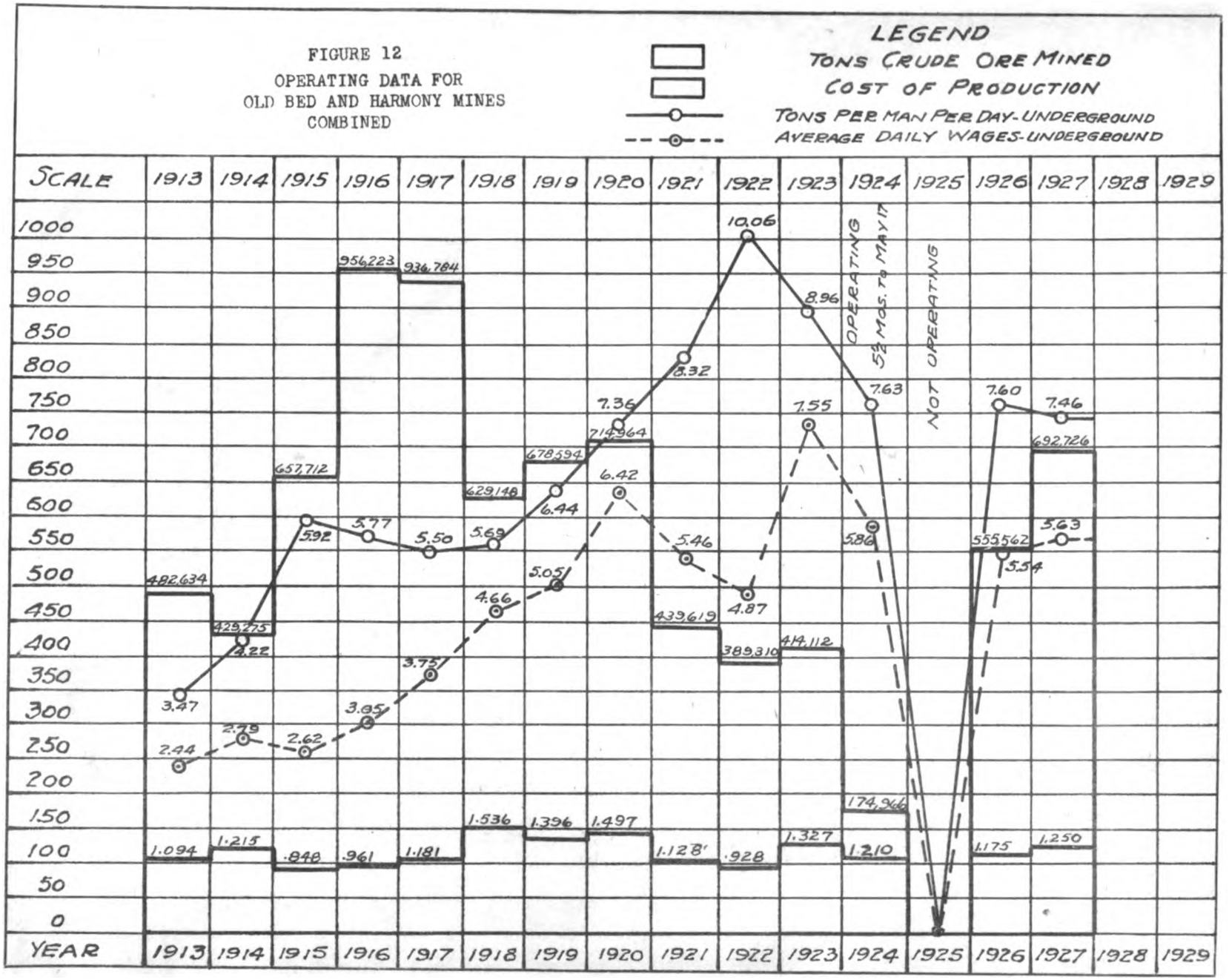
FIGURE 12

OPERATING DATA FOR
OLD BED AND HARMONY MINES
COMBINED



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